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**The Hypersatellite Spectrum of Vanadium**

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Beamline(s): X25

Hypersatellite (HS) spectra, originating in atoms having an empty K shell, provide important and often unique information on intra-shell electronic correlations, the Breit interaction and QED effects in atoms. Most importantly, they allow studying the variation with Z of the coupling from LS to jj [1,2]. The 3d transition metals (Z=22-30) are most important for these studies since they reside at the transition region from LS to Intermediate coupling. Continuing our previous study of the Z variation of these HS, we have measured the first resolved $K^h\alpha$ HS spectrum of vanadium. We have also measured its intensity variation from threshold, which should provide information on the excitation/de-excitation process' variation in the "adiabatic" regime near threshold. Finally, both $K^h\,\alpha$ and $K^h\,\beta$ HS were measured with the same setup, allowing their cross-sections to be compared accurately.

Monochromatized incident energy was used, tuned from below-threshold (~11keV) to 20 keV. The emission spectrum was analyzed by a Johann spectrometer, employing a spherically bent Si(331) analyzer at a near back-reflection Bragg angle, providing ~1.5 eV resolution.

Fig. 1 shows a very tiny $K^h\,\alpha_1$ and an intense $K^h\,\alpha_2$ lines as expected from the $K^h\,\alpha_1$ HS being spin-flip forbidden in LS coupling. This line was not observed even for the higher-Z Cr until our recent measurements. The agreement of the splitting, position and lineshapes of the measured spectrum with the *ab-initio* calculated spectrum shown in the lowest panel is very good. This is indicated by the good fit (red line in uppermost panel) obtained by representing each *ab-initio* calculated line by a Voigt function, and fitting their (common) width and an overall intensity factor to of the measured spectrum. The good quality of the fit is demonstrated by the small residuals in the center panel, almost all of which are bounded by $\pm 2\sigma$ of the measured data. The measured $K^h\,\alpha_1$/ $K^h\,\alpha_2$ intensity ratio, which measures sensitively the intermediacy of the coupling, is ~20% lower than calculated, indicating that correlations (not included in the calculations) may have a bigger effect than hitherto assumed.

**References:**

[1] R. Diamant et al., Phys. Rev. Lett. **84**,3278 (2000) ; Phys. Rev. A. **62**, 52519 (2000) .

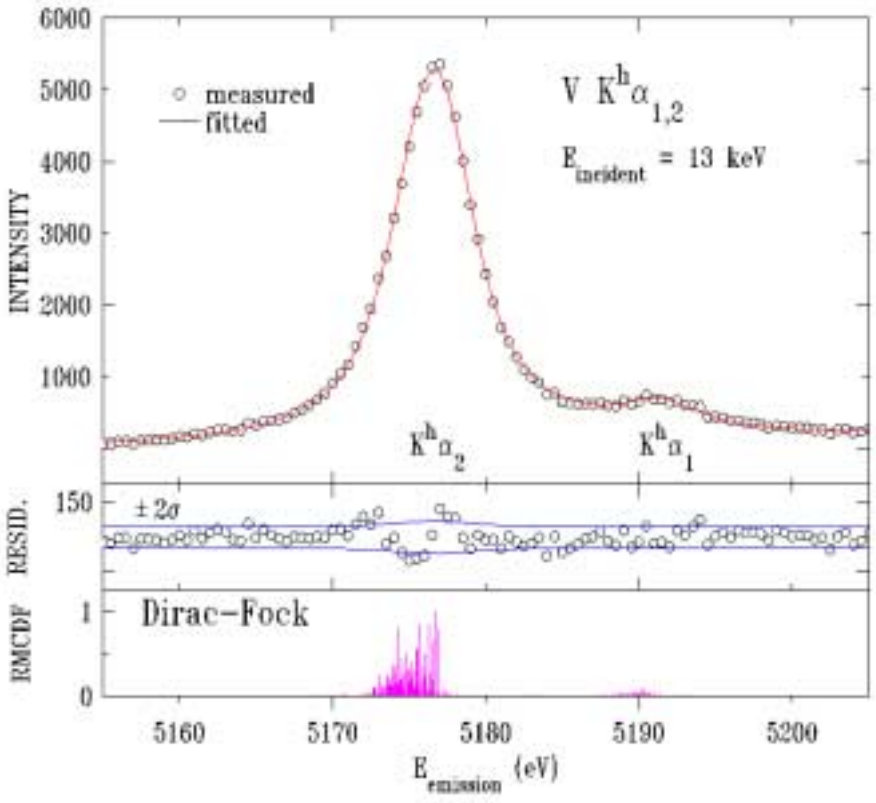


**Fig. 1**: The measured (points) and fitted (red line) hypersatellite $K^h\,\alpha$ spectrum of vanadium. The fit residuals are almost all within two standard deviations of the measurements, indicating a good fit. The *ab-initio* Dirac-Fock calculated spectrum is shown in the lowest panel